BENDING OF BEAMS

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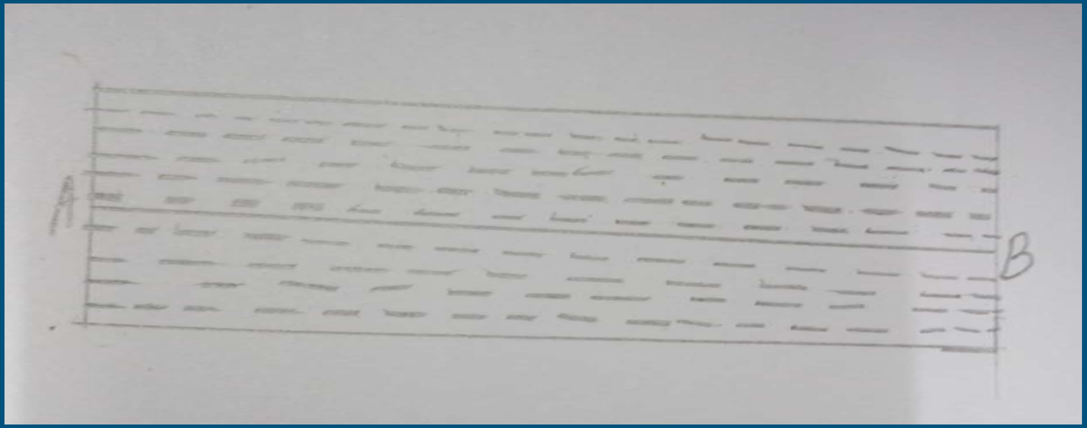
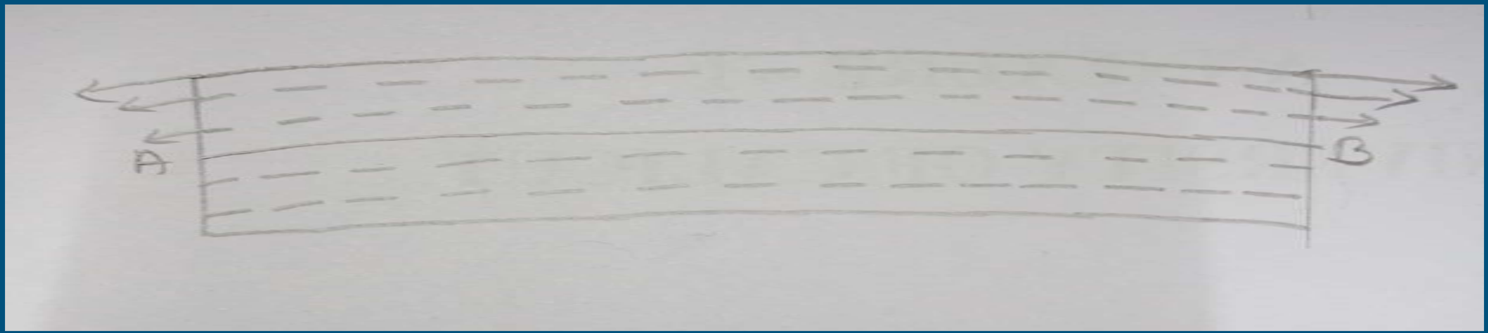
A beam is defined as a structure of uniform cross section whose length is large in comparison to its breadth and thickness.

Beams are used in the construction of bridges or for purposes of supporting heavy loads.



The beam is considered as made up of large no. of thin plane layers arranged parallel to each other.



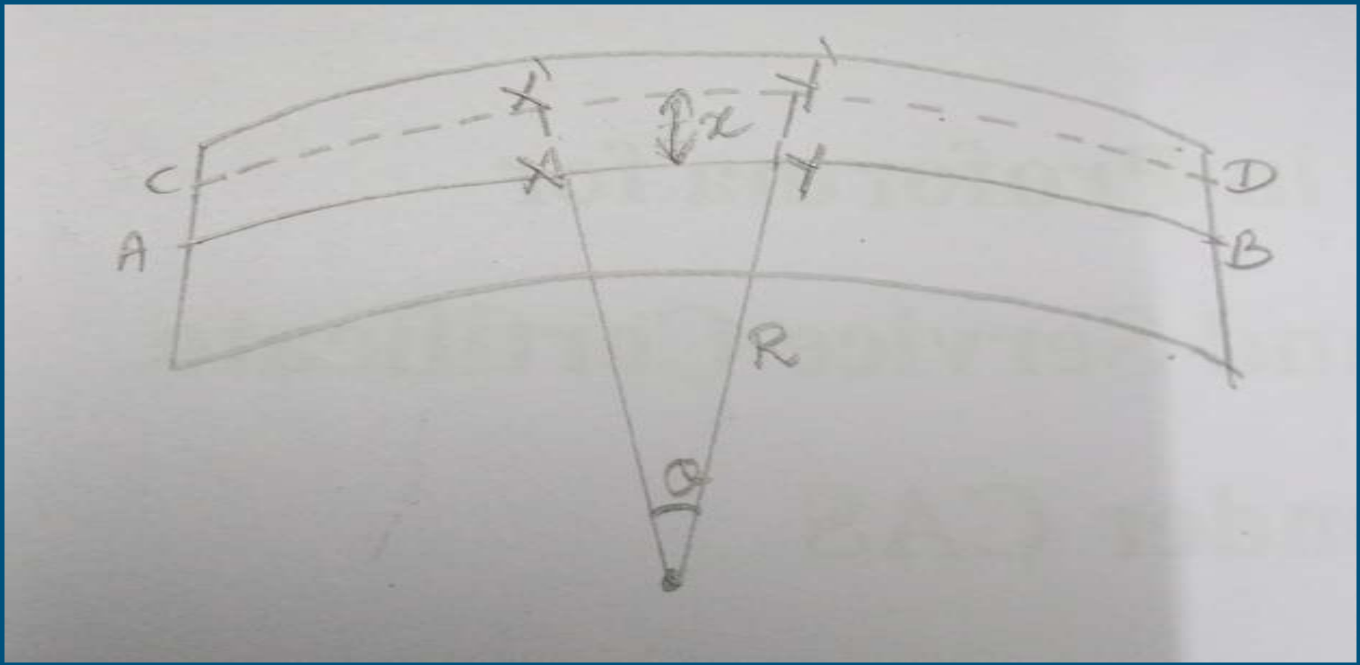
Let the beam subjected to deforming forces ,the beam bends.

When the deforming forces are applied,layers above AB are elongated and layers below AB are compressed.

The length of the layer AB remains unaltered.It is called Neutral axis.

The change in length of any layer either elongation or contraction is proportional to the distance of the layer from the neutral axis.

Bending Moment-Moment of the force required to bend a beam



Consider the portion of a layer X^IY^I at a distance of x above the neutral axis.The neutral axis bends to the form of a circle of radius R subtending an angle Ɵ at its centre

For small angles,XY=RƟ

X^IY^I=(R+x)Ɵ

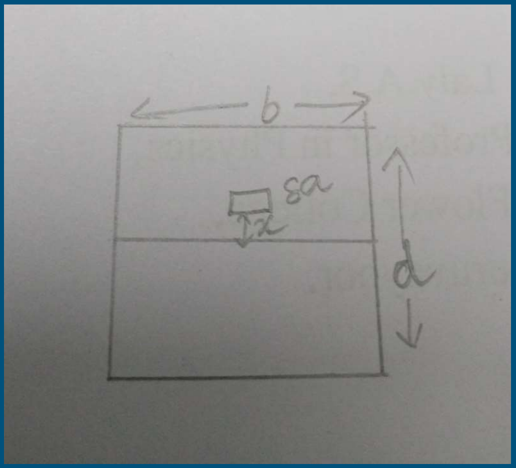
Increase in length=X^IY^I-XY=(R+x)Ɵ-RƟ=xƟ

Strain=x/R

Stress =Y x Strain=Yx/R

The force acting on the area of cross section δa is =stress x δa

$$F = \frac{Yx}{R} \times \delta a$$



The forces producing elongation act on

the upperhalf outward and those producing

contraction act on lower half inward .

These two forces constitute a couple.Moment of the force about the neutral axis

$$= \left(\frac{Yx}{R} \delta a \right) x = \frac{Yx^2}{R} \delta a$$

The moment of all the forces about the neutral axis

$$= \sum \frac{Yx^2}{R} \delta a = \frac{Y}{R} \sum x^2 \delta a$$

$$Here \sum x^2 \delta a = AK^2 = I$$

Where A is the area of cross section of the beam and K is the radius of gyration, $AK^2=I$ is called geometrical moment of inertia of the beam.

$$BendingMoment = \frac{YI}{R} = \frac{YAK^2}{R}$$

Special cases:

1.RECTANGULAR CROSS SECTION

If the breadth of the beam is b and the thickness is d,then $A=bd$ and $K^2 = d^2/12$

$\therefore I=AK^2=bdd^2/12 = bd^3/12$

The bending moment of rectangular beam$=YAK^2/R = Ybd^3/12R$

2.CIRCULAR CROSS SECTION

Here $A=\pi r^2$ and $K^2=r^2/4$

$I=AK^2=\pi r^4/4$

The bending moment of a circular beam$=Y\pi r^4/4R$

Flexural Rigidity

It is defined as the external bending moment required to produce a unir radius of curvature.

Flexural Rigidity=YI

BASIC ASSUMPTIONS TAKEN FOR THEORY OF BENDING

- The length of the beam is large in comparison to the thickness of the beam.
- The Young’s modulus of the beam has the same value for elongation as well as compression.
- The cross section of beam remains unchanged during bending and hence the value of geometrical moment of inertia is constant
- The applied forces are large in comparison to the weight of the beam.

I -form girders

When a beam is depressed due to load ,the layers above the neutral surface extended and layers below the neutral surface get compressed.

The compression or extension is proportional to the distance from the neutral surface.

Hence stresses produced in the beam are maximum at the upper and lower surfaces of the beam.

Therefore the girders must be strong at the upper and lower surfaces of the beam.That is why the iron girders used in buildings are made of I-form.

- ***This type of cross section provides high bending moment and a lot of material is saved.***